



Annual Reports :: Year 6 :: Groupement de Recherche en Exobiologie

Team Reports: Groupement de Recherche en Exobiologie

Groupement de Recherche en Exobiologie

Executive Summary

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GDR CNRS 1877, or Groupement de Recherche en Exobiologie, is a national federation of research laboratories in Exo/Astrobiology, created by the National Centre of Scientific Research (CNRS) in 1999 and renewed in 2003. Its main goal is to promote, induce and coordinate the development of Exo/Astrobiology scientific programs in France. It includes about 50 laboratories, and is supported by the CNRS and CNES (the French Space Agency).

4 main research topics are addressed:

- The ingredients of primitive life in their geological, planetological, and interstellar context
 - From the chemistry of the origins of life to the emergence of life: structures and functions of biological molecules
 - Terrestrial life as a reference: fossils, biomarkers, extreme environments
 - Habitats and signatures of extraterrestrial life
- GDR Exobio has a scientific council consisting of 19 scientists from different fields, including astrophysics, planetology, physics, chemistry, earth sciences, life sciences, as well as philosophy and epistemology. The GDR has been affiliated with the NAI since November 2001.

Main recent activities

During the period July 2003–June 2004, the GDR Exobio, within the framework of its main 4 topics, has been active in several directions directly connected to NAI activities. Below are just a few examples of these activities, with the corresponding references given in the Reference List.

Several important results on Titan's organic chemistry have been obtained on the potential presence of oxirane and ammonia on Titan (Bernard et al., 2003; Coll et al., 2003). GDR members have participated in the CIRS–Cassini observation of Jupiter (Flasar et al., 2004). New evidences that POM may be a precursor of formaldehyde in comets has been obtained through laboratory experimental data and modeling (Cottin et al., 2004; Fray et al., 2004). Dual column gas chromatograph system has been developed for in situ analysis of a

cometary nucleus (Szopa et al., 2004).

Our efforts were also devoted to investigate one of the most important biological aspects of the origins of life, the RNA world hypothesis. We discovered two co-ribozymes that are new hairpin ribozymes dependent on a prebiotic compound: adenine (Meli et al., 2003). On the other hand, we were able to show by Surface Enhanced Raman Spectroscopy (SERS) the detection of subpicomolar amount of nucleic acid components trapped on mineral surfaces (Elamri et al., 2003). We also studied the adsorption of adenine in meteorite specimens (Elamri et al., 2004a) and the micro-distribution of carbonaceous matter in Murchison meteorite by Raman imaging (Elamri et al., 2004b).

New data have been obtained in the field of biomarkers and the search for fossil biofilms (Westall et al., 2003). The same team has organized two scientific meetings in 2004 related to these topics: a workshop in Les Treilles , France , and an EGU session in Nice. In addition, Philippe Labrot, a graduate student of the team, has created a website dealing with Mars and the origin of life at <http://www.nirgal.net/>.

New effects of the accretion of juvenile micrometeorites on the birth of life on the early Earth have been recently discovered. They focus on very high input rates of micrometeoritic SO₂ and smoke particles in the thermosphere, after the formation of the Moon. SO₂ ended up being temporarily stored as sulfates, which were recycled by hydrothermal sources, thus assisting the functioning of the sulfides and thioesters "worlds" of exobiology. Altogether with CO₂ and H₂O, also injected in the thermosphere by micrometeorites, SO₂ and smoke particles probably played a dominant role in the early greenhouse effect, at a time when the optical thickness of the cloud of smoke particles (about 10) made the early Sun looking like the full Moon (Maurette et al., 2003, 2004 a, b).

Our studies on extremophiles focus on the mechanism of DNA repair, recombination and replication in extreme conditions (high temperature and exposure to high doses of gamma rays). We have isolate new radioresistant hyperthermophiles of the domain Archaea (Jolivet et al., 2003b, 2004), including the most radioresistant hyperthermophiles known, *Thermococcus gammatolerans*. This archaeon is nearly as resistant than *Deinococcus radiodurans*. We have recently completed the sequencing of its whome genome. We also have isolate new enzymes from hyperthermophiles, including the first bipolar helicase (Constantinesco et al., 2004). We are currently searching for viruses from hyperthermophilic environments from different collections of hyperthermophiles, including a new one recently characterized at the molecular level (Lepage et al., 2004). A first virus of anaerobic hyperthermophiles has been isolated (Geslin et al., 2003). Our phylogenetic analyses point to a hyperthermophilic ancestr of archaea and have possibly revealed a novel mechanism that controls the rate of genome evolution (Brochier et al., 2004). They also suggest a very important role of viruses in early cellular evolution (Filée et al., 2003) and probably in the transition between the RNA and the DNA world (Forterre et al., 2004). We have previously shown that DNA was probably invented twice independently in the course of evolution (Myllykallio et al., 2002).

We have analyzed how rings of extrasolar planets may lead to a wrong determination in the planet radius from its thermal emission, and we have shown that the analysis of the planet light curve in reflected light circumvents this source of error.

Exobio'03, the 3rd bi-annual National exo/astrobiology summer school took place in Corsica in September, 2003. As for the 2 previous schools, it was attended by about 80 participants coming from astronomy and geophysics, chemistry and biology. The program of this 7-day school included four main topics: (i) evolution of complex systems, and auto-organization; (ii) time scales in astronomy, geology, chemistry and biology; (iii) impacts and volcanism; and (iv) interstellar chemistry. The second item was also the main topic of a dedicated 3-day workshop organized by M. Gargaud in St-Emilion (a well known vineyard) attended by 15 participants, which should induce a larger reflection on this problem and a joint publication.

References

- Arnold L. and Schneider J. (2004). The Detectability of Extrasolar Planet Surroundings: I. Reflected Light Photometry of Unresolved Rings. *Astron. & Astrophys.* **420**, 1153.
- Bernard J.M., Coll P., Coustenis A., and Raulin F. (2003). Experimental Simulation of Titan's Atmosphere : Detection of Ammonia and Ethylene Oxide. *Planet. Space Sci.* **51** (14-15), 1003-1011 (2003).
- Brack A. and Leclercq B. (2003). *La Vie est-elle Universelle?* EDP Sciences (2003).
- Brack, A. (2004). *Et la Matière Devint Vivante*, Le Collège de la Cité, Editions Le Pommier.
- Brochier C., Forterre P., and Gribaldo S. (2004). Archaeal Phylogeny Based on Proteins of the Transcription and Translation Machineries: Tackling the *Methanopyrus Kandleri* Paradox, *Genome Biology* **5**, R17.
- Constantinesco F., Forterre P., Koonin E., Aravind L., and Elie C. (2004). A Bipolar DNA Helicase Gene, *herA*, Clusters with *rad50*, *mre11* and *nurA* Genes in Thermophilic Archaea, *Nucleic Acids Res.* **32**, 1439-1447.
- Cottin H., Bénilan Y., Gazeau M.-C., and F. Raulin F. (2004). Origin of Cometary Extended Sources From Degradation of Refractory Organics on Grains: Polyoxymethylene as Formaldehyde Parent Molecule. *Icarus* **167**, 297-416.
- ElAmri C., Maurel M.-C, Sagon G., and Baron M.-H. (2004b). The Micro-distribution of Carbonaceous Matter in the Murchison Meteorite as Investigated by Raman Imaging. *Spectrochimica Acta*, in press.
- ElAmri C., Baron M.-H., and Maurel M.-C. (2004a). Adenine Adsorption onto and Release from Meteorite Specimens Assessed by Surface Enhanced

Raman Spectroscopy. *Journal of Raman Spectroscopy* **35** , 170–177.

Elamri C., Baron M–H., and Maurel M–C. (2003). Adenine in Mineral Samples. Surface Enhanced Raman Spectroscopy for Picomolar Detection. *Spectrochimica Acta A*, **59** , 2645–2654 .

Filée J., Forterre P., and Laurent J. (2003). The Role Played by Viruses on the Evolution of Their Cellular Host : A View on Informational Proteins Phylogenies, *Res. In Microbiol.*, **15** , 237–243.

Flasar M., Kunde V., Achterberg R., Conrath B., Simon–Millere A., Nixon C., Gierrach P., Romani P., Bézard B., Irwin P., Bjoraker G., Brasunas J., Jennings D., Pearl J., Smith M., Orton G., Spilker L., Carlson R., Calcutt S., Read P., Taylor F., Parrish P., Barucci A., Courtin R., Coustenis A., Gautier D., Lellouch E., Marten A., Prange R., Biraud Y., Fouchet T., Ferrari C., Owen T., Abbas M., Samuelson R., Raulin F., Ade P., Cesarsky C., Grossman K., and Coradini A. (2004). An Intense Stratospheric Jet on Jupiter. *Nature* **427** , 132–135.

Forterre P., Filée J., and Myllykallio H. (2004). Origin and Evolution of DNA and DNA Replication Machineries. The Genetic Code and the Origin of Life, L. Ribas, ed. Landes Bioscience.

Fray N., Bénilan Y., Cottin H., and Gazeau M.–C. (2004). New Experimental Results on the Degradation of Polyoxymethylene: Application to the Origin of the Formaldehyde Extended Sources in Comets. *J. Geophys. Res.* **109** (EO7S12), in press.

Fray N., Bénilan Y., Cottin H., Gazeau M.–C., Minard R.D., and Raulin F. (2004). Experimental Study of the Degradation of Polymers. Application to the Origin of Extended Sources in Cometary Atmospheres. *Meteoritics and Planetary Science* , **39** (4), 581–587.

Geslin C., Le Romancer M., Erauso G., Gaillard M., Perrot G., and Prieur D. (2003). PAV1, The First Virus–like Particle Isolated from a Hyperthermophilic Euryarchaeote, " *Pyrococcus Abyssii* ". *J Bacteriol.* **185** (13), 3888–94.

Jolivet E., Corre E., L'Haridon S., Forterre P., and Prieur D. (2004). *Thermococcus Marinus* sp. nov., and *Thermococcus Radiotolerans* sp. nov., two Hyperthermophilic Archaea from Deep–sea Hydrothermal vents that Resist Ionizing Radiation, *Extremophiles* , in press.

Jolivet E., L'Haridon S., Corre E., Forterre P., and Prieur D. (2003). *Thermococcus Gammatolerans* sp. Nov., a Hyperthermophilic Archaeon From Deep–sea Hydrothermal Vents that Resists to Ionizing Radiation , *Inter. J. Syst . Microbiol.* **53** , 847–851.

Jolivet E., Matsunaga F., Ishino Y., Forterre P., Prieur D., and Myllykallio H. (2003). Mechanism Resistance to γ –Irradiation of the Hyperthermophilic Archaeon *Pyrococcus Abyssii* : Evidence for an Efficient Repair of the Double–strand Breaks, *J. Bacteriol.* **185** , 3958–3961.

- Lepage E., Marguet E., Geslin C., Matte-Taillez O., Zillig W., Forterre P., and Matte-Taillez P. (2004). Molecular Diversity of New Thermococcales Isolates From a Single Area of Hydrothermal Deep-sea Vents as Revealed by Randomly Amplified Polymorphic DNA Fingerprinting and 16S rRNA Gene Sequence Analysis, *Appl Environ Microbiol* . **70** , 1277–1286.
- Matsunaga F., Norais C., Forterre P., and Myllykallio H. (2003). Identification of Short 'Eukaryotic' Okazaki Fragments Synthesized From a Prokaryotic Replication Origin, *EMBO reports* **4** , 154–158.
- Maurette M., Matrajt G., Gounelle M., Duprat J., Engrand C., Blanot D. (2003). "Juvenile" KBOs Dust; Prebiotic Organic Chemistry. *Frontier of Life* , Eds. Celniquier L.M., Trần Thanh Vân J. (Thê Gioi Publishers, Vietnam), pp. 7–22.
- Maurette M., Brack A., Duprat J., Engrand C., and Kurat G. (2004a). High Input Rates of Micrometeoritic Sulfur, "Smoke" Particles and Oligoelements on the Early Earth. *Lunar Planet. Sci* . **XXXV** , A1625.
- Maurette M., Brack A., Duprat J., Engrand C., Hammer C., and Kurat G. (2004b). Micrometeoritic Cosmic "Volcanism" in Exobiology. *Origins Life Evol. Biosphere* , submitted.
- Meli M., Vergne J., and Maurel M-C. (2003). In Vitro Selection of Adenine-dependent Hairpin Ribozymes. *J. Biol. Chem.* **278** (11), 9835–9842.
- Myllykallio H., Lipowski G., Leduc D., Filée J., Forterre P., and Liebl U. (2002). Identification of An Alternative Flavin Dependent Mechanism for Thymidylate Synthesis, *Science* **297** , 105–107.
- Szopa C., De Pra M., Tellini I., Sternberg R., Pietrogrande M.C., Vidal-Madjar, C., and Raulin F. (2004). Dual Column Capillary C chromatographic System for the In Situ Analysis of Volatile Organic Compounds on a Cometary Nucleus. *J. Sep. Sci.* **27** , 495–503.
- Westall F. (2003). Stephen Jay Gould, Les Procaryotes et Leur Evolution Dans le Contexte Géologique. *Palevol* **2** , 485–501.
- Westall F., Hofmann B., and Brack A. (2004). Searching for Fossil Microbial Biofilms on Mars: A Case Study Using a 3.46 Billion-Year Old Example From the Pilbara in Australia . *Proceedings of the Third European Workshop on Exo/Astrobiology Madrid , Spain 18–20 2003*, **ESA Spec. Pub** . **545** , 37–40.
- Westall F., Walsh M.M., Toporski J., and Steele A. (2003). Fossil Biofilms and the Search for Life on Mars. In *Fossil and Recent Biofilms*, eds. W.E. Krumbein, D. Patterson, G. Zavarzin, Kluwer, Amsterdam , 447–465.
- Westall, F., and Folk R.L., (2003). Exogenous Carbonaceous Microstructures in Early Archaean Cherts and BIFs From the Isua Greenstone Belt: Implications for the Search for Life in Ancient Rocks. *Precambrian Res* . **126** , 313.

Future Hopes

The GDR wishes to participate in cooperative programs of research, on clearly identified topics, in the framework of its affiliation to NAI. The NAI connection should be a great opportunity to share and exchange researchers, in particular Ph.D. students, to promote joint participation in research programs on Exo/astrobiology, and to use the synergy induced by the different ways of thinking and working of researchers from different origins to promote the wide field of Exo/astrobiology. Targets such as Titan, in relation to Cassini–Huygens, Mars and its international program of exploration, and Europa and Extrasolar planets are already among the topics of high interest likely to be part of such joint research projects. In addition, the need for networking, with new and efficient tools for teleconferencing (including asynchronous communication) remains a technical priority.

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